

## Supplementary Information

### Clarifying the preferential occupation of Ga<sup>3+</sup> ions in YAG:Ce,Ga nanocrystals with various Ga<sup>3+</sup>-doped concentration by nuclear magnetic resonance spectroscopy†

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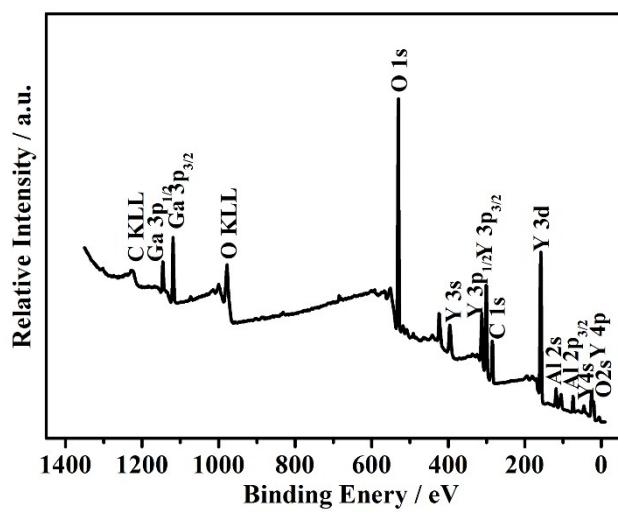
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**Table S1.** Assignments of FTIR spectra for the precursor and product of YAG:Ce,Ga (sample-3), YAG:Ce (sample-7) and YAG (sample-6) nanophosphors.

Peak no.	Precursor	Sample-3 100 °C	Sample-3 930 °C	Sample-7 930 °C	Sample-6 930 °C	Assignments	Ref.
1	—	—	484	480	—	$\delta(\text{Ga}/\text{Al}=\text{O})$ in $\text{AlO}_6$ , $\nu(\text{Y}-\text{O})$	38
2	—	—	—	—	571	$\nu(\text{Ga}/\text{Al}=\text{O})$ in $\text{AlO}_6$	39
3	601	—	641	628	628	$\delta(\text{Al}=\text{O})$ in $\text{AlO}_4$	39
4	—	—	690	691	692	$\nu(\text{Al}=\text{O})$ in $\text{AlO}_4$	38
5	—	—	720	723	729	$\nu(\text{Y}/\text{Ce}=\text{O})$	37, 38
6	—	—	786	788	792	$\nu(\text{Al}=\text{O})$ in $\text{AlO}_4$	38
7	—	—	1051	1051	1051	$\delta(\text{O}-\text{H})$	34
8	1088	—	—	—	—	$\nu(\text{C}-\text{O})$	34
9	1385	—	—	—	—	$\nu(\text{N}-\text{O})$ in $\text{NO}_3^-$	31
10	1448	—	—	—	—	$\nu(\text{COO})$	31
13	1633	—	1630	1628	1623	$\nu(\text{COO}), \delta(\text{H}-\text{O}-\text{H})$	31, 32
14	3421	—	3421	3421	3421	$\nu(\text{O}-\text{H})$	31

$\nu$ : stretching vibration,  $\delta$ : bending vibration.



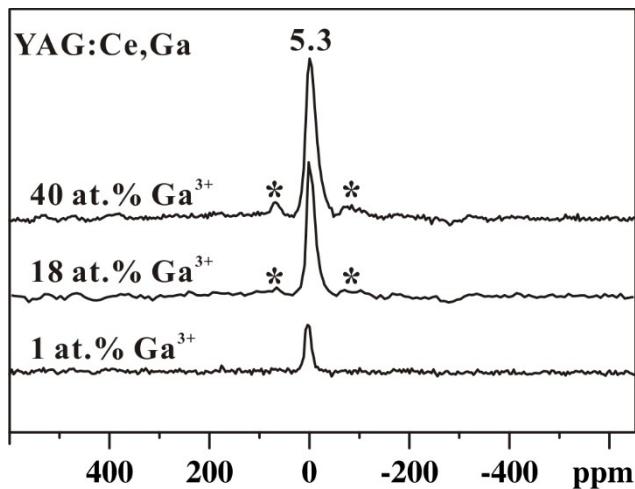
**Fig. S1** Overview XPS of YAG:Ce,Ga (sample-3) nanophosphors in the 0 – 1350 eV binding energy region.

**Table S2.** The simulated parameters of AlO<sub>4</sub> species obtained by the quantitative <sup>27</sup>Al MAS NMR spectra.

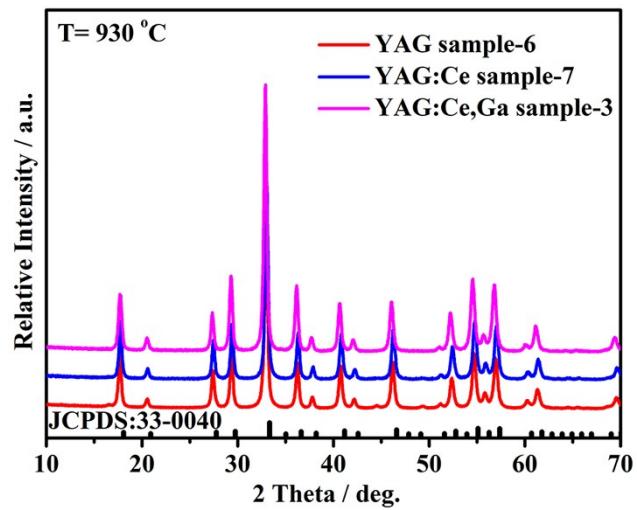
No.	Sample	$\lambda_{iso}$ /ppm	CQ/MHz	$\eta$
1	YAG:Ce,Ga sample-1	77.1	6.101	0.022
2	YAG:Ce,Ga sample-3	77.1	6.113	0.018
3	YAG:Ce,Ga sample-5	76.7	6.043	0.011
4	YAG:Ce sample-6	77.8	6.085	0.065
5	YAG sample-7	78.1	6.109	0.063

**Table S3.** The simulated parameters of GaO<sub>6</sub> species obtained by the quantitative <sup>71</sup>Ga MAS NMR spectra.

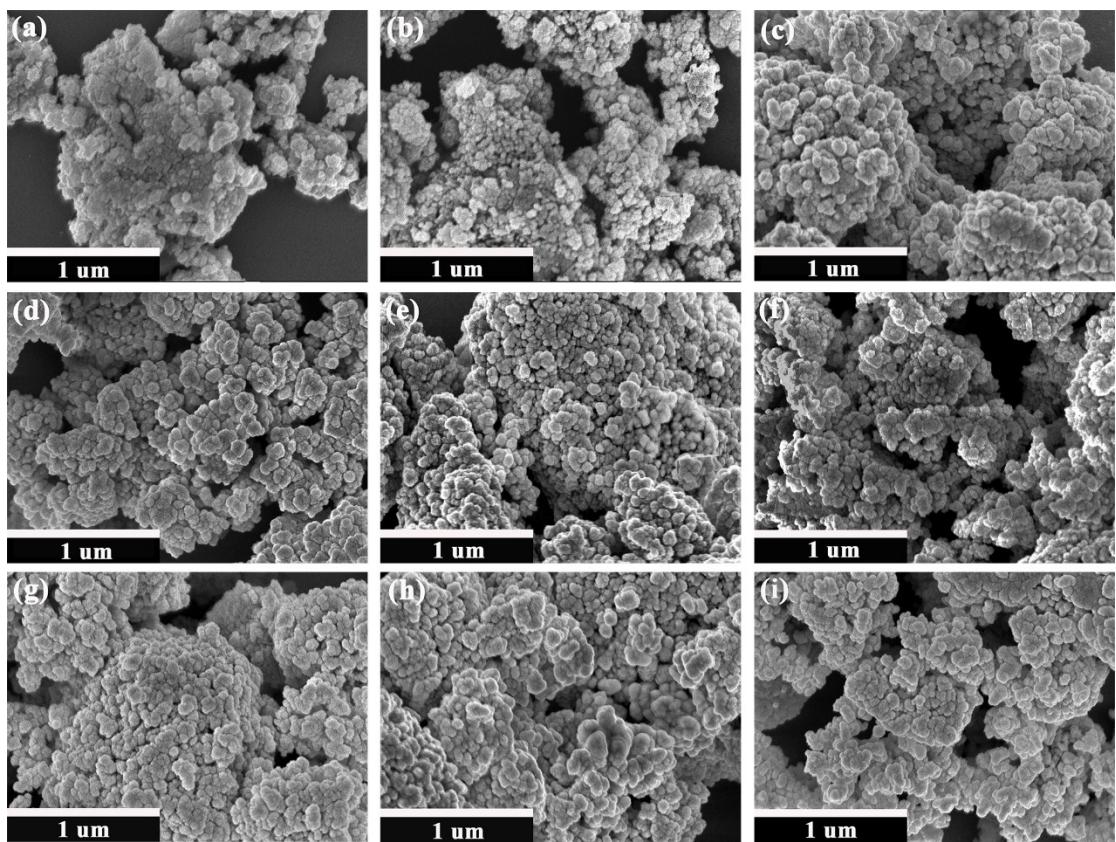
No.	Sample	$\lambda_{\text{iso}/\text{ppm}}$	CQ/kHz	$\eta$	Area / 100mg
1	YAG:Ce,Ga sample-1	14.0	2942	0.109	12287314
2	YAG:Ce,Ga sample-3	13.9	3170	0.221	35692246
3	YAG:Ce,Ga sample-5	12.8	3467	0.284	58309337



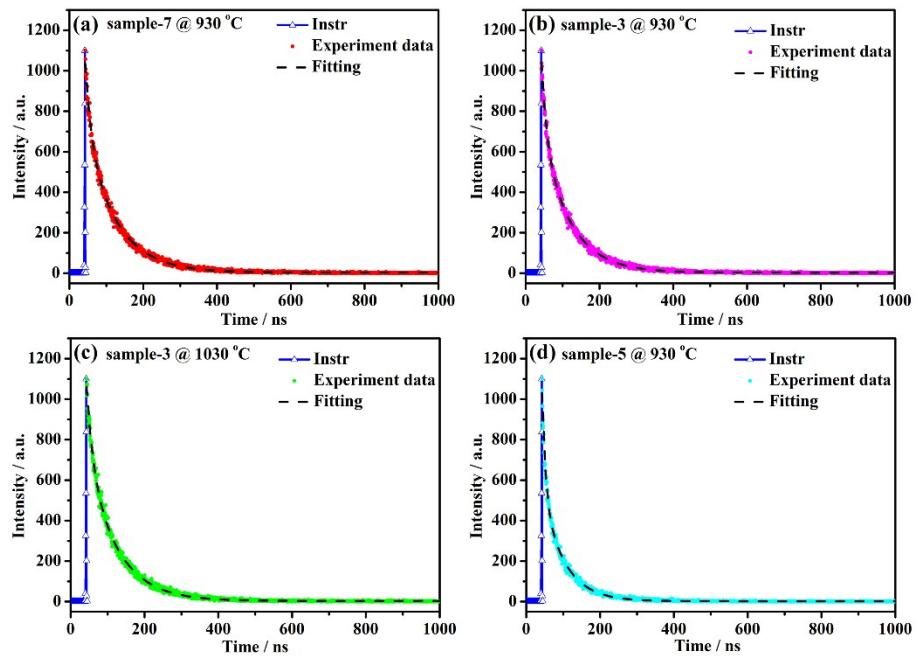
**Fig. S2**  $^{71}\text{Ga}$  MAS NMR spectra of YAG:Ce,Ga nanophosphors with different codoping  $\text{Ga}^{3+}$  concentrations. All the samples were sintered at 930 °C. Spin rate is 10 kHz and the asterisks stand for spinning bands.



**Fig. S3** XRD patterns of YAG (sample-6), YAG:Ce (sample-7) and YAG:Ce,Ga (sample-3) nanocrystals.



**Fig. S4** SEM images of (a – e) YAG:Ce,Ga (sample-3) nanophosphors sintered at different temperatures (830, 880, 930, 980 and 1030 °C) and (c and f – i) YAG:Ce,Ga (sample-1 to -5) nanophosphors with different Ga<sup>3+</sup>-doped concentration sintered at 930 °C.



**Fig. S5** PL decays of YAG:Ce (sample-7@930 °C) (a), YAG:Ce,Ga (sample-3@930 °C) (b), YAG:Ce,Ga (sample-3@1030 °C) (c) and YAG:Ce,Ga (sample-5@930 °C) nanophosphors (d) ( $\lambda_{\text{ex}}=454$  nm,  $\lambda_{\text{ex}}=525$  nm).